Dual-Phase Inorganic Membrane for High Temperature Carbon Dioxide Separation

Jerry Y.S. Lin
S. Chung
Duo Li

University of Cincinnati
Department of Chemical & Material Engineering
Cincinnati, OH 45221-0171

Phone: (513)556-2672
Fax: (513)556-3473
E-mail: jlin@alpha.che.uc.edu

DE-FG26-02NT41555

09/01/03 – 08/31/04

Abstract

This project is aimed at synthesis of a new inorganic dual-phase carbonate membrane for high temperature CO_2 separation. Metal-carbonate dual-phase membranes were prepared by the direct infiltration method and the synthesis conditions were optimized. The dual-phase membranes are gas-tight with helium permeance about six orders of magnitude lower than that for the metal support. Efforts were made to test seals for permeation and separation experiments for dual-phase membrane at the intermediate temperature range (about 500^{o}C) under oxidizing atmosphere. An effective new permeation cell with a metal seal was designed, fabricated and tested. The permeation setup provided leak-free sealing for the dual-phase membranes under the desired operation conditions.

Gas permeance of CO_2, N_2, and CO_2 with O_2 was measured at various temperatures (450-750^{o}C). Permeance of carbon dioxide with oxygen increases with temperature while permeance of other gases has a weak temperature dependence. Permeance of CO_2, N_2, and CO_2 with O_2 was in the range of 9-10 x 10^{-10}, 3-10 x10^{-10}, and 2-6 x 10^{-9} mol/s.m.^{2} Pa, respectively at 450-650^{o}C. At 650^{o}C, permeance of carbon dioxide with oxygen reached maximum, which was 16 times higher than that of nitrogen. At higher temperature permeance of all gases decreased dramatically after a few hour permeation experiments possibly due to oxidation of the metal support or dissolution of metal to the molten carbonate. Research on the metal-carbonate dual phase membrane continues with efforts to avoid deactivation of the membrane.

Research efforts were also directed towards preparation of a new ceramic-carbonate dual- phase membrane. Porous lanthanum cobaltite (LC) perovskite type oxide ceramic support with oxidation resistance better than the metal support and high electronic conductivity (1300-1500 S/cm in 400-600^{o}C), was prepared and studied as an alternative support for the dual-phase carbonate membranes. The LC powder was found not reactive with the carbonate at 600^{o}C. The porous LC disks have helium permeance

and pore diameter smaller than the metal support but larger than the common α-alumina support. These results show promise to use the LC support for preparation of oxidation resistant dual-phase carbonate membranes.